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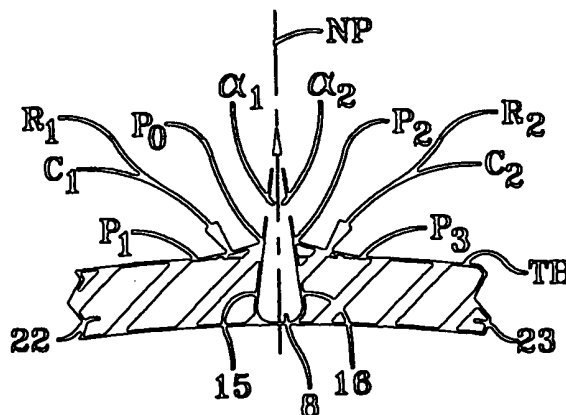
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: <b>PCT/US97/18031</b></p> <p>(22) International Filing Date: <b>3 October 1997 (03.10.97)</b></p> <p>(71) Applicant (for all designated States except US): <b>THE GOODYEAR TIRE &amp; RUBBER COMPANY [US/US]; 1144 East Market Street, Akron, OH 44316-0001 (US).</b></p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): <b>FONTAINE, Jean, François, Leon [LU/LU]; 14, UM Kettenhouscht, L-9142 Buerden (LU).</b></p> <p>(74) Agent: <b>KING, David, L.; The Goodyear Tire &amp; Rubber Company, Dept. 823, 1144 East Market Street, Akron, OH 44316-0001 (US).</b></p>		<p>(81) Designated States: <b>AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b></p> <p>Published With international search report.</p>

(54) Title: **TREAD FOR A PNEUMATIC TIRE**

(57) Abstract

A tread (2) for a pneumatic tire (1) has a central portion defining two circumferentially extending center ribs (22, 23) having an axial width RW, and RN<sub>2</sub> ranging from 5 % to 25 % of the tread width TW. The centermost circumferentially extending groove (8) has on both sides a tapered groove wall edges which form with a plane parallel to the equational plane acute angle  $\alpha_1$  and  $\alpha_2$  ranging between 1 and 10°. The tread height near both edges of the centermost groove extend radially above the average tread height a maximum extra tread height of between .3 mm and 1.7 mm. The extra tread height diminishes progressively from the groove edges P<sub>0</sub>P<sub>1</sub> towards the respective shoulder (3, 4) a distance not exceeding 10 % of the tread width.



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**TREAD FOR A PNEUMATIC TIRE****Technical Field**

5       The present invention relates to a tread for a pneumatic radial tire.

**Background Art**

10       The tread portion of a pneumatic tire generally comprises an elastomeric material having a plurality of grooves therein defining ground engaging rubber elements. The particular size and shape of these elements contributes significantly to the overall performance of the  
10   tire. Tire treads are generally designed to provide a particular performance, such as for instance winter, high traction or high speed performance. Thus obtaining of one particular performance characteristic is often at odds with obtaining another one.

15       Hydroplaning of tires on wet pavement has long been a problem in the prior art. Various tire designs, adapted to channel water away from the tire, and thereby maintain  
15   rubber contact with the road have been created. Although prior art rain tire designs, such as described e.g. in EP-A- 508 090, have improved wet traction, it is a continuing goal in the art to further improve such.

20       French patent 1 214 717 teaches a way to improve road adherence by providing the tread pattern with raised block elements. The raised elements are described as acting as  
20   elastic, heavily compressed projections entering the small holes in the road surface and improving thereby the grip of the tire. US patent 5 343 918 discloses a tire tread with at least one circumferentially extending row of high stiffness blocks and one of low stiffness blocks. The low stiffness blocks have a radial height between 4% and 10% superior to the radial height of the high stiffness blocks. The object is to obtain uniform handling response and to  
25   improve grip.

      It is an object of the present invention to provide a pneumatic tire having improved wet traction while maintaining good handling, noise and irregular wear characteristics.

      Other objects of the invention will be apparent from the following description and claims.

**30   Disclosure of Invention**

      A tread 2 for a pneumatic tire 1 has elastomeric material. The tread 2 has a central portion and two lateral portions 3,4, each lateral portion having circumferentially and laterally extending grooves defining ribs or lugs therein.

35       The central portion includes three laterally spaced circumferentially extending grooves 7,8,9, defining two circumferentially extending center ribs 22, 23 having an axial width RW ranging from 5 % to 25 % of the tread width TW of the ground engaging tread portion.

The centermost circumferentially extending groove 8 has on both sides tapered groove wall edges  $P_0$ ,  $P_2$ , which form with a plane NP parallel to the equatorial plane EP acute angles  $\alpha_1$  and  $\alpha_2$  ranging between 1 and 10 degrees, preferably between 2 and 7 degrees, more preferably between 3 and 5 degrees. The tread height near both edges of the centermost groove extending radially above the average tread height a maximum extra tread height comprised of .3 mm and 1.7 mm most preferably between .8 and 1.2 mm. This extra tread height diminishes progressively from the groove edges towards the respective nearest shoulder of the tire over a distance not exceeding 10% of the tread width.

Preferably the circumferentially extending center ribs 22, 23 are cut by sipes 14 and may include blind grooves 52, 53.

The width of the circumferentially extending centermost groove at 8, 53, 68, 77 the tread surface is between 5 and 20 mm and the groove is spaced from the equatorial plane a distance equaling at most 25 % of the treadwidth TW.

The tread 2 is delimited by a first and a second shoulder 3, 4 and having a central portion and two lateral portions. Each lateral portion has circumferentially and laterally extending grooves defining ribs or lugs. The central portion includes three laterally spaced circumferentially extending grooves defining two circumferentially extending center ribs having an axial width RW ranging from about 5 % to 25 % of the tread width TW of the ground engaging tread portion.

The centermost circumferentially extending groove has on both sides tapered groove edges, which form with a plane parallel to the equatorial plane acute angles  $\alpha_1$  and  $\alpha_2$  ranging between 1 and 10 degrees.

In an axial cross section of the tread 2, the radially outer tread surface, on a first side and second side of the centermost groove, has at least a first and at least a second radius of curvature  $R_1$  and  $R_2$  respectively. The first radius of curvature  $R_1$  has its center  $C_1$  radially outwardly of the tread surface, in a plane parallel to the equatorial plane and located between the first side of the center groove and the first shoulder of the tire,  $R_1$  extends from a point  $P_0$  on the edge the groove wall forms with the tread surface to a point  $P_1$  located a distance between 5 % and 15 % of the treadwidth, defining thereby a first radially outer convex tread surface.

The second radius of curvature  $R_2$ , has its center  $C_2$  radially outwardly of the tread surface, in a plane parallel to the equatorial plane and located between the second side of the center groove and the second shoulder of the tire.  $R_2$  extends from a point  $P_2$  on the edge the groove wall forms with the tread surface to a point  $P_3$  located a distance between 5 % and 15 %

of the treadwidth, defining thereby a second radially outer convex tread surface.

The centers of curvature  $C_1$  and  $C_2$  lie preferably in a plane located from the respective edges of the centermost groove they define, a distance ranging between 5% and 10% of the treadwidth. The point  $P_1$  is spaced from  $P_0$  a distance of about 7% of the tread width and the point  $P_3$  is spaced from  $P_2$  a distance of about 7% of the treadwidth.

#### Definitions

"Aspect Ratio" of the tire means the ratio of its section height to its section width.

"Bead" means that part of the tire comprising an annular tensile member wrapped by ply cords and shaped, with or without other reinforcement elements such as flippers, chippers, apexes, toe guards and chaffers, to fit the design rim.

"Carcass" means the tire structure apart from the belt structure, tread, undertread, and sidewall rubber over the plies, but including the beads.

"Crown" refers to the circumferentially outermost portion of the carcass substantially within the width limits of the tread.

"Design rim" means a rim having a specified Configuration and width.

"Directional tread" refers to a tread design which has a preferred direction of rotation in the forward direction of travel.

"Equatorial plane (EP)" means the plane Perpendicular to the tire's axis of rotation and passing through the center of its tread.

"Footprint" means the contact patch or area of contact of the tire tread with a flat surface at zero speed and under design load and pressure.

"Footprint Net-to-gross" refers to the actual footprint of a deflected tire and is the ratio of the ground contacting surface area of the tread to the total tread footprint area including the groove void area.

"Groove" means an elongated void area in a tread that may extend circumferentially or laterally about the tread in a straight, curved, or zig-zag manner. Grooves ordinarily remain open in the tire footprint. Circumferentially and laterally extending grooves sometimes have common portions and may be sub-classified as "wide" or "narrow". Grooves may be of varying depths in a tire. If such narrow or wide grooves are of substantially reduced depth as compared to wide circumferential grooves which they interconnect, they are regarded as forming "tie bars" tending to maintain a rib-like character in the tread region involved.

"Sipes" refers to small slots molded into ribs or lugs of a tire that subdivides the tread surface and improves traction characteristics. Sipes tend to close completely in a tire footprint.

"Lugs" refer to discontinuous radial rows of tread rubber in direct contact with the road surface.

"Normal load and inflation pressure" refers to the specific design inflation pressure and load assigned by the appropriate standards organization for the design rim and service condition for a tire of specific size. Examples of standards are the Tire and Rim Association Manual and the European Tire and Rim Technical Organization.

"Pneumatic tire" means a laminated mechanical device of generally toroidal shape (usually an open-torus) having beads and a tread and made of rubber, chemicals, fabric and steel or other materials. When mounted on the wheel of a motor vehicle, the tire through its tread provides traction and contains the fluid that sustains the vehicle load.

"Radial" and "radially" are used to mean directions radially toward or away from the axis of rotation of the tire.

"Rib" means a circumferentially extending strip of rubber on the tread which is defined by at least one circumferential "wide groove" and either a second such groove or a lateral edge of the tread, the strip of rubber being laterally undivided by full-depth narrow or wide grooves.

"Shoulder" refers to the upper portion of sidewall just below the tread edge.

"Sidewall" means that portion of a tire between the tread and the bead.

"Tread" means a molded rubber component which, when bonded to a tire casing, includes that portion of the tire that comes into contact with the road when the tire is normally inflated and under normal load.

"Tread width" means the arc length of the road contacting tread surface in the axial direction, that is, in a plane parallel to the axis of rotation of the tire.

#### **Brief Description of Drawings**

Figure 1 is a perspective view of a tire embodying a tread made in accordance with the present invention.

Figure 2 shows a footprint of the tread of the tire of figure 1.

Figure 3 is a cross-section of the footprint shown in figure 2, along the line III-III.

Figure 4 is a detailed cross-section of the center part of the tread of figure 1.

Figure 5 is a footprint of a directional tread according to the invention.

Figure 6 shows the footprints of two asymmetrical directional tire treads according to the invention.

Figure 7 is a footprint of a high performance low aspect ratio tire according to the invention.

### Detailed Description of the Invention

Referring to Figures 1 and 2, there is represented a pneumatic tire 1 including in its crown region a tread 2 made in accordance with the present invention. The tire 1 is of the radial type construction and designed for use on passenger vehicles. The tread 2 is delimited by a first shoulder 3 and a second shoulder 4. Sidewalls 5 connect the shoulders 3, 4 to the beads 6. The tread 2 includes three circumferentially extending straight grooves 7, 8, 9 and two sets of laterally extending grooves 20 and 21. The various grooves are respectively laterally and circumferentially spaced apart across the surface of the tread and divide the tread into circumferentially extending ribs 22 and 23 near the equatorial plane EP and rows of blocks 11, 12 near the shoulders 3, 4 of the tire.

The two ribs 22, 23 have respectively an axial width  $RW_1$  and  $RW_2$  and extend substantially an equal distance on either side of the equatorial plane EP. The widths  $RW_1$  range each from 5 % to 25 % and preferably from 10 % to 15 % of the tread width TW of the ground engaging tread portion. The width of the circumferentially extending centermost groove 8 at the tread surface is between 5 and 20 mm.

The laterally extending grooves 20 and 21 near the shoulders 3, 4 are disposed circumferentially about the tire in a repetitive manner, their widths and inclinations depending on the pitch variation, as is practiced in the industry for noise reduction. The grooves 20 and 21 may form opposed angles with the equatorial plane so as to give a directional tire, as e.g. represented in Fig. 5. or -as represented- the grooves 20 and 21 may make complementary angles with the equatorial plane so as to provide a non directional tire.

In a preferred embodiment, the ribs 22, 23 are cut by narrow grooves, i.e. grooves having a width ranging between 0.5 % to 2 % of the treadwidth, or by sipes 14. The narrow grooves or sipes 14 have preferably an inclination with respect to the equatorial plane ranging between 30 and 60 degrees.

Though the invention may be implemented in any passenger and light truck tire, low aspect ratio tires where the length of the contact patch in the footprint is smaller than the treadwidth TW are of special interest. In tires having aspect ratios below 60 the invention provides a most desirable increase of the hydroplaning speed.

In order to facilitate the flow of water out of the middle portion of the contact patch of the tire footprint, the centermost circumferentially extending groove 8, which is either cut by, or is spaced from the equatorial plane EP a distance equaling at most 25 % of the treadwidth, preferably at most 10 %, has on both sides tapered groove edges. Such can be distinguished in Figure 3. In an axial section of the tire, the angles  $\alpha_1$ ,  $\alpha_2$  formed respectively by the

uppermost portion of a first and second lateral side 15, 16 of the groove 8 with a plane NP parallel to the equatorial plane are acute, so that the distance between the opposing sidewalls of the groove diminishes radially outwardly. The angles  $\alpha_1$  range between 1 and 10 degrees, and are preferably between 2 and 7 degrees and more preferably between 3 and 5 degrees.

- 5 The groove walls form with a plane NP parallel to the equatorial plane, such negative taper angle from the tread surface of a new tire down to 1-3 mm above the groove bottom. In a preferred embodiment of the invention the angles formed by groove portions on the same sidewall at different radial heights are substantially similar. In case the center groove 5 is not located in the middle of the tread, choosing different taper angles for the opposing sidewalls  
10 might be of advantage.

Reference is now more specifically made to Figure 4. Jointly with the negatively by tapered groove wall angles  $\alpha_1$ , the tread height near both edges  $P_0, P_2$  of the centermost groove 8 extends above the average tread height TH and this extra tread height diminishes progressively from the groove edges  $P_0, P_2$  towards the respective shoulders 3, 4 of the tire on a  
15 distance not exceeding 10%, preferably not exceeding 5% of the treadwidth. At both centermost groove sidewalls, the tread extends radially between .3 mm and 1.7 mm, preferably between .6 and 1.4 mm and most preferably between .8 and 1.2 mm above the average tread height TH. Put in other words, in an axial cross section of the tread, the radially outer tread surface, on a first side 15 and a second side 16 of the centermost groove 8,  
20 has respectively a first and second radius of curvature  $R_1, R_2$  wherein the first radius of curvature  $R_1$ , having its center  $C_1$  radially outwardly of the tread surface, in a plane located between the first side 15 of the center groove and the first shoulder 3 of the tire, extends from a point  $P_0$  on the edge, the groove wall 15 forms with the tread surface, to a point  $P_1$  located a distance between 5% and 15% of the treadwidth, defining thereby a first radially outer convex  
25 tread surface; the second radius of curvature  $R_2$ , having its center  $C_2$  radially outwardly of the tread surface, in a plane located between the second side 16 of the centermost groove and the second shoulder 4 of the tire, extends from a point  $P_2$  on the edge, the groove wall 16 forms with the tread surface to a point  $P_3$  located a distance between 5% and 15% of the treadwidth defining thereby a second radially outer convex tread surface.

- 30 The centers of curvature  $C_1$  and  $C_2$  lie preferably in a plane parallel to the equatorial plane located from the respective edges  $P_0$  and  $P_1$  a distance ranging between 5% and 10% of the treadwidth.

The radii of curvature,  $R_1$  and  $R_2$ , are substantially similar and range between 5 mm and 30 mm. More preferably, the radii of curvature range between 10 mm and 20 mm.



In a further embodiment of the invention, the radially outer tread surface of the tread near the centermost groove is defined by two or three different radii on one or both sides of the groove. The farther the centers of curvature lie away from the groove wall, the longer the radii are.

5 It is understood that the remaining portions of the tread surface are defined by the usual two or three radii of curvature, having values comprised between 150 mm and infinity, whereby the centers of curvature lie radially inwardly of the tread surface they define.

The effect of the design according to the invention is explained in Figure 2 where the flow of water in a tire has been represented. The raised groove edges 30 contact the ground  
10 or the water on the ground a few millimeters before the other portions of the tread. Similarly these same groove edges are the last portions of the tread to leave the footprint and define thereby the maximum length L of the footprint.

If the road is covered by water, the groove edges 30 impart a flowing movement to the water which flowing movement is normal to the leading footprint edge. As in the present case  
15 the leading footprint edge presents a convex curvature to the water, the latter is pushed sideward out of the middle of the footprint. This beneficial effect of the invention based on the shape of the leading edge of the footprint is boosted by the jet of water 31, squeezed out of the centermost groove 8 as the tread enters the footprint. The water jet enhances the effect of the convex curvature of the center portion of the leading footprint edge and initiates lateral water  
20 flow 32 in front -and out of- the footprint. The shape or length of this water jet depends on the car speed, the water depth and resulting water pressure buildup, the exact design and tread depth of the tire, the pavement below the water etc. Though the length of the water jet diminishes continuously as the car speed increases and disappears at speeds above 90 km/h, the combined effect of the convex leading edge of the footprint together with the water jet will  
25 be a significant increase of the aquaplaning resistance of a tire in deep water.

Figure 5 represents a footprint of a directional tread according to the invention which tread is symmetrical with respect to the equatorial plane of the tire. In this embodiment of the invention, the tread includes three circumferentially extending straight grooves, and four sets  
30 of laterally extending grooves 50, 51, 52, 53. The various grooves are respectively laterally and circumferentially spaced apart across the surface of the tread and divide the tread into circumferentially extending ribs near the equatorial plane EP and rows of blocks near the shoulders of the tire.

The two ribs, which are defined by the two circumferentially extending shoulder grooves 58, 59 and the center groove 57, are adjacent to the equatorial plane EP. The ribs

include circumferentially spaced blind grooves 52 and 53, originating in the shoulder grooves 58, 59. The laterally extending grooves 50, 51 near the shoulders of the tire are disposed circumferentially about the tire in a repetitive manner, defining thereby lugs 54. The ribs and the lugs 54 may include sipes so as to optimize noise and wear properties of the tire; the sipes  
5 may be straight, curved or zigzag like and they may have the same depth as the neighboring grooves or varying depths. In order to improve the aquaplaning resistance of this directional design, the center groove 57 has a section as represented in figure 4.

Figure 6 shows on its left side a footprint of an asymmetrical directional tire tread to be mounted on the left side of a car and on its right side a footprint of an asymmetrical  
10 directional tire tread to be mounted on the right side of a car. The forward travel direction of the car is represented by an arrow. Though only two circumferentially extending grooves 67, 68 have been represented, three or more may be foreseen. Groove 68, having a section as represented in figure 4, is delimited by two ribs 61, 62 which, as explained above with respect to figure 5, include blind grooves 63, 64 and sipes. The remaining circumferentially extending  
15 groove or grooves cooperate with laterally extending groove so as to define rows of blocks. Groove 68, is positioned towards the outer side of the car at a distance from the equatorial plane EP comprised between 10% and 30% of the treadwidth.

Figure 7 shows a footprint of a high performance low aspect ratio tire according to the invention. By low aspect ratio tire is meant here a tire having an aspect ratio below 55. The  
20 tread includes three circumferentially extending grooves 76, 77, 78 wherefrom the middle groove 77 is preferably a so-called aqua channel as e.g. described in EP-A- 508 090. The rubbery material -lugs or ribs- adjacent to aqua channel 77 is contoured into the aqua channel, such that in a transverse section, the aqua channel has a curved U shape (having a rounded bottom and curved sides) favoring evacuation of large amounts of water. In each of the  
25 shoulders of the tire is located a groove, 76 respectively 78, having a cross section as shown in figure 4. If the road is covered by water, the edges of the grooves 76 and 78 impart a flow to the water, which is normal to each of the leading footprint edges. The water is pushed sideward to the shoulders, out of the footprint and towards the middle of the tire in front of the aqua channel 77.

30 The invention is further illustrated by the following example: A steel belted radial carcass tire of size 225/70 R 16 has a tread width of about 160 mm, two center ribs and 2 rows of blocks. The rows of blocks are molded to have axial widths  $RW_1$  and  $RW_3$  of about 30 mm and 35 mm respectively.

The nominal tread depth is about 9 mm, and the widths of the grooves depend on their

axial position in the tread and the pitch variation. The circumferentially extending grooves have a width of about 30 mm.

Two carcass plies comprise 1100/2 dtex polyester reinforcement cords and an uncured cord density of 30 ends per inch (EPI) was used in the construction. The belt structure of an  
5 uncured tire comprises two single cut plies reinforced by 2+2x0.25 mm steel cords, having a cord density of about 22 EPI, forming uncured angles of about 23° with the equatorial plane, the angles of the cables in different plies extending in opposite directions.

The tread has a net to gross of 58% to 73% and comprises an elastomeric compound having a modulus of 4 to 16 MPa, a Shore A hardness of 60 to 75, an elongation greater than  
10 300% and a tensile strength at break greater than 15 MPa.

While certain representative embodiments have been described for the purpose of illustrating the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the claims.

## CLAIMS

1. A tread for a pneumatic tire comprising elastomeric material, said tread having a central portion and two lateral portions,
  - each lateral portion having circumferentially and laterally extending grooves defining ribs or lugs therein;
  - the central portion including three laterally spaced circumferentially grooves, defining two circumferentially extending center ribs having an axial width RW ranging from 5 % to 25 % of the tread width TW of the ground engaging tread portion;
  - the centermost circumferentially extending groove having on both sides tapered groove wall edges, which form with a plane parallel to the equatorial plane acute angles  $\alpha_1$  and  $\alpha_2$ , ranging between 1 and 10 degrees; and
  - the tread height near both edges of the centermost groove extending radially above the average tread height a maximum extra tread height comprised between .3 mm and 1.7mm, this extra tread height diminishing progressively from the groove edges towards the respective nearest shoulder of the tire on a distance not exceeding 10% of the treadwidth.
2. A tread for a pneumatic tire according to claim 1, wherein the circumferentially extending center ribs are cut by sipes.
3. A tread for a pneumatic tire according to claim 1, wherein the circumferentially extending center ribs includes blind grooves.
4. A tread for a pneumatic tire according to claim 1, wherein the width of the circumferentially extending centermost groove at the tread surface is comprised between 5 and 20 mm.
5. a tread for a pneumatic tire according to claim 1, wherein the centermost circumferentially extending groove is spaced from the equatorial plane a distance equaling at most 25 % of the treadwidth TW.
6. A tread for a pneumatic tire according to claim 5, wherein the angles  $\alpha_1$  range between 2 and 7 degrees and more preferably between 3 and 5 degrees.
7. A tread for a pneumatic tire according to claim 1, wherein the extra tread height at the edges of the centermost groove is comprised between .3 and 1.7 mm and most preferably between .8 and 1.2 m.
8. A tread for a pneumatic tire comprising elastomeric material, said tread being delimited by a first and a second shoulder and having a central portion and two lateral portions, each lateral portion having circumferentially and laterally extending grooves defining

ribs or lugs therein;

- each lateral portion having circumferentially and laterally extending grooves defining

ribs or lugs therein;

- the central portion including three laterally spaced circumferentially extending

5 grooves defining two circumferentially extending center ribs having an axial width RW ranging from about 5 % to 25 % of the tread width TW of the ground engaging tread portion;

- the centermost circumferentially extending groove have on both sides tapered groove edges, which form with a plane parallel to the equatorial plane acute angles  $\alpha_1$  and  $\alpha_2$ , ranging between 1 and 10 degrees;

10 - in an axial cross section of the tread, the radially outer tread surface, on a first side and second side of the centermost groove, has at least a first and at least a second radius of curvature  $R_1$  respectively  $R_2$ ;

- wherein the first radius of curvature  $R_1$ , having its center  $C_1$  radially outwardly of the tread surface, in a plane parallel to the equatorial plane and located between the first side

15 of the center groove and the first shoulder of the tire,  $R_1$  extends from a point  $P_0$  on the edge the groove wall forms with the tread surface to a point  $P_1$  located a distance between 5 % and 15 % of the treadwidth, defining thereby a first radially outer convex tread surface; and

- wherein the second radius of curvature  $R_2$ , having its center  $C_2$  radially outwardly of the tread surface, in a plane parallel to the equatorial plane and located between the second

20 side of the center groove and the second shoulder of the tire, extends from a point  $P_2$  on the edge the groove wall forms with the tread surface to a point  $P_3$  located a distance between 5 % and 15 % of the treadwidth, defining thereby a second radially outer convex tread surface.

9. A tread for a pneumatic tire according to claim 8, wherein the centers of the curvature  $C_1$  and  $C_2$  lie preferably in a plane located from the respective edges of the centermost groove

25 they define, a distance ranging between 5 % and 10 % of the treadwidth.

10. A tread for a pneumatic tire according to claim 8, wherein the point  $P_1$  is spaced from  $P_0$  a distance of about 7 % of the tread width and the point  $P_3$  is spaced from  $P_2$  a distance of about 7 % of the tread width.

11. A tread for a pneumatic tire according to claim 0, wherein in place of one radius of

30 curvature, there are two different radii  $R_1$  of curvature on at least one side of the centermost groove, the centers of curvature of said radii lying farther away from the respective groove wall, the longer the radii are.

12. A tread for a pneumatic tire having an aspect ratio below 55, comprising elastomeric material, said tread having a central portion and two lateral portions, the different portions

having equal widths;

- the central portion including a circumferentially extending aqua channel, wherein the rubbery material adjacent to the aqua channel is contoured into the aqua channel, such that in a transverse section, the aqua channel has a curved U shape, favoring evacuation of large

5 amounts of water;

- each lateral portion including a circumferentially extending groove, delimited by circumferentially extending ribs, the groove having on both sides tapered groove wall edges, which form with a plane parallel to the equatorial plane acute angles  $\alpha_1$  and  $\alpha_2$ , ranging between 1 and 10 degrees, the tread height near both edges of the said groove extending  
10 radially above the average tread height a maximum extra tread height comprised between .3 mm and 1.7 mm, this extra tread height diminishing progressively from the groove edges towards the respective shoulder of the tire on a distance not exceeding 10% of the tread width.

13. The tread according to claim 12 wherein the said circumferentially extending aqua channel is cut into two equal halves by the equatorial plane.

15 14. The tread according to claim 12 wherein the said circumferentially extending grooves in the two lateral portions, cut the two lateral portions into The tread as described above has preferably two substantially equal halves.

15. The tread according to claim 12 wherein the circumferentially extending ribs in the lateral portions are cut by blind grooves which do not extend into the groove defined by the  
20 two ribs.

16. The tread according to claim 12 wherein each of the two lateral portions include, apart from the circumferentially extending groove demarcated by the two ribs, at least a further circumferentially extending groove cooperating with at least one series of circumferentially spaced laterally extending grooves so as to define rows of lugs.

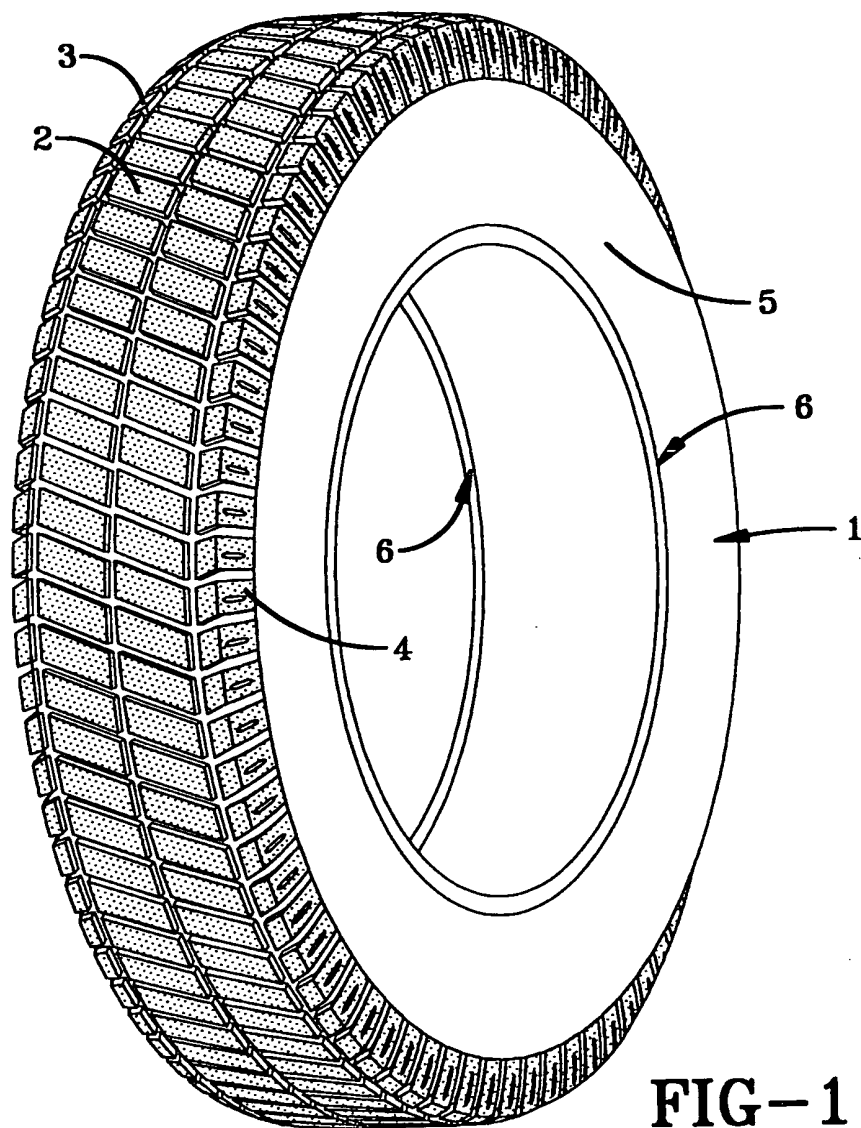


FIG-1

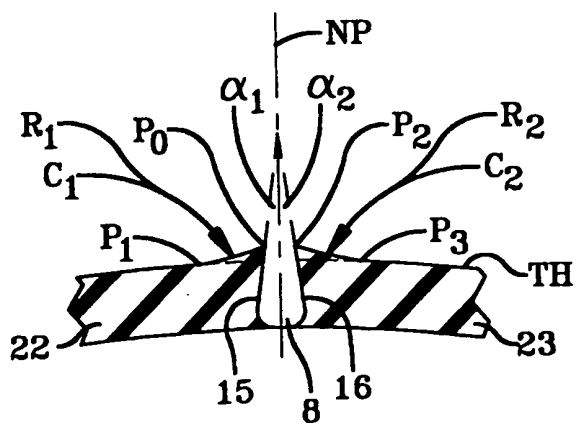


FIG-4

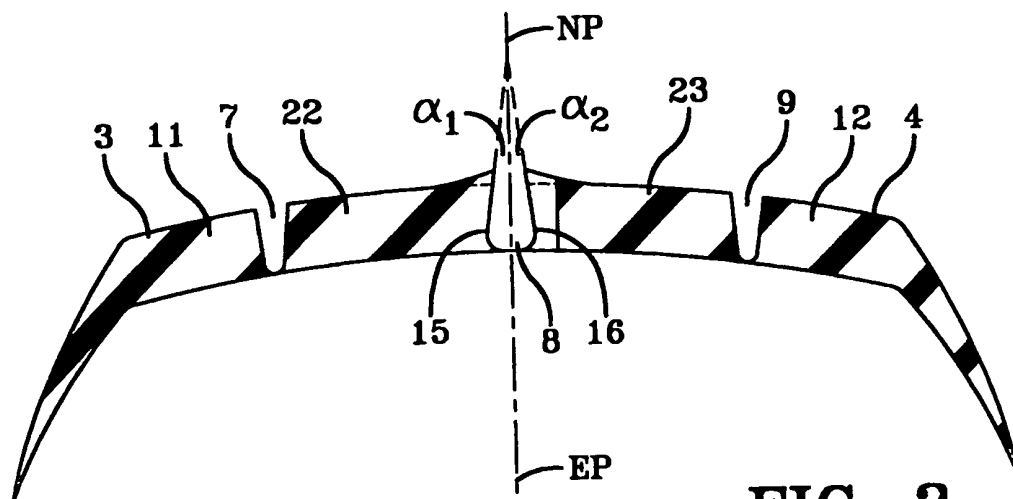


FIG-3

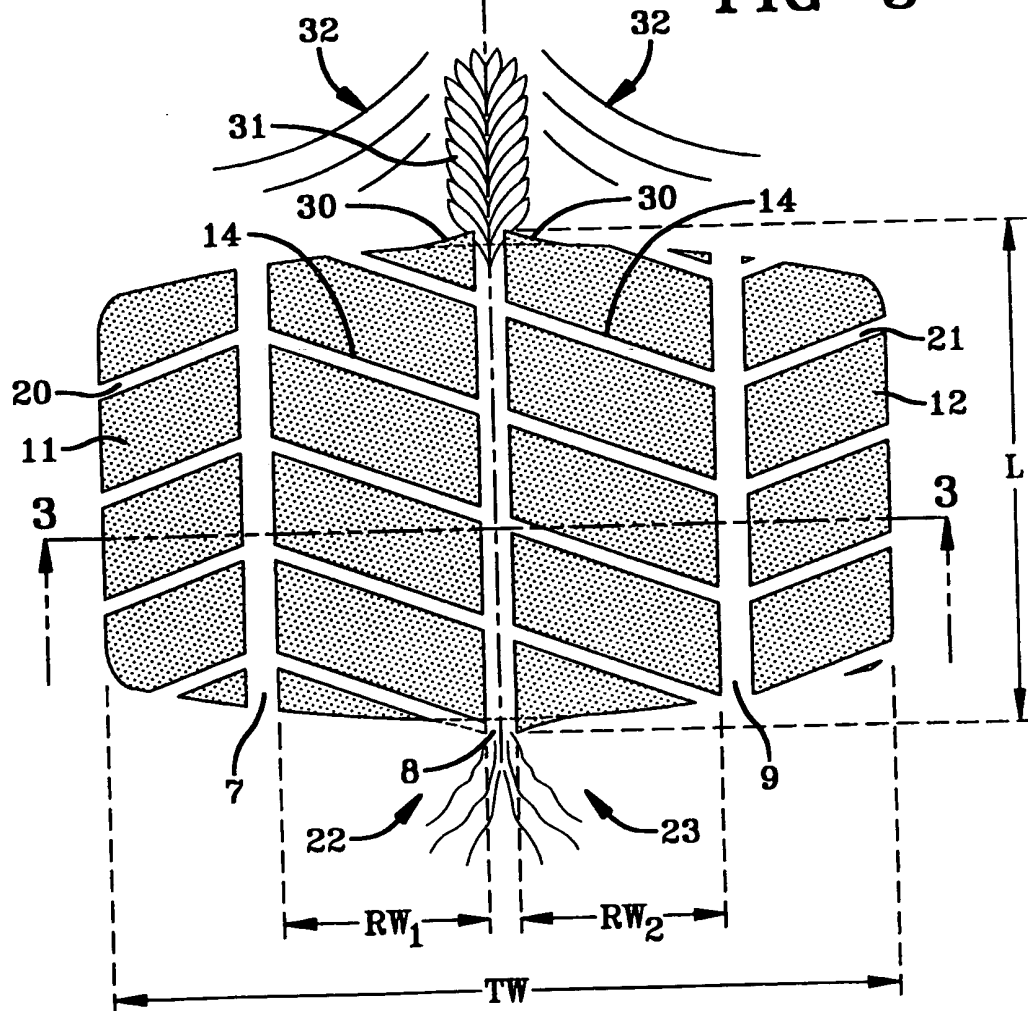


FIG-2



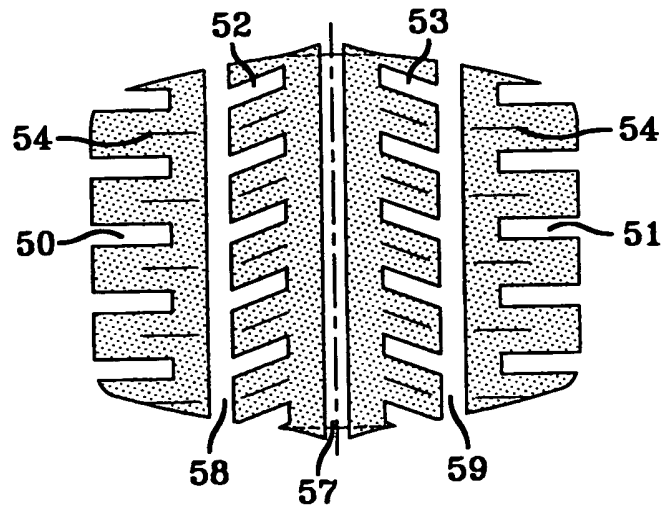


FIG-5

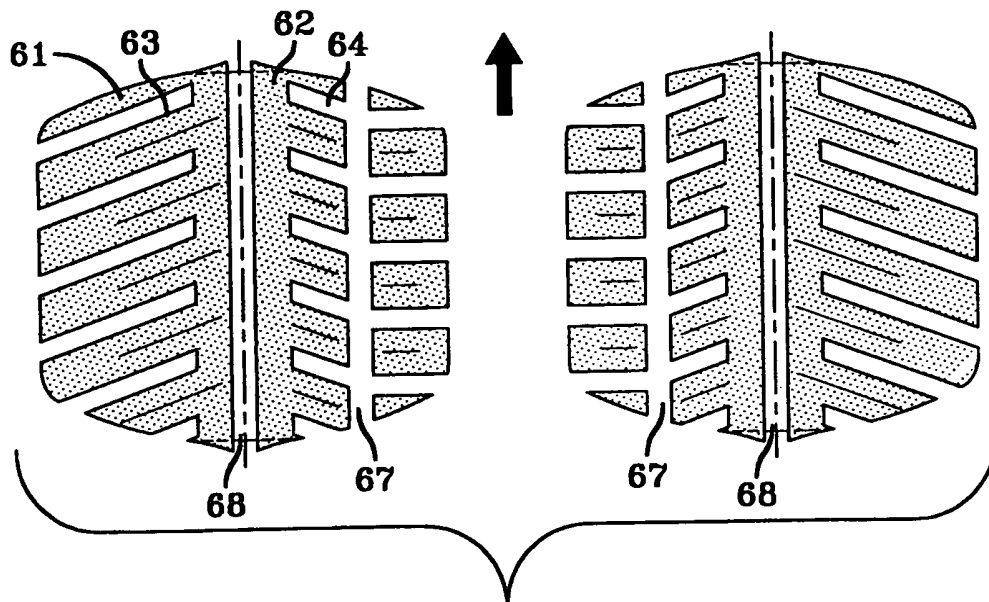


FIG-6

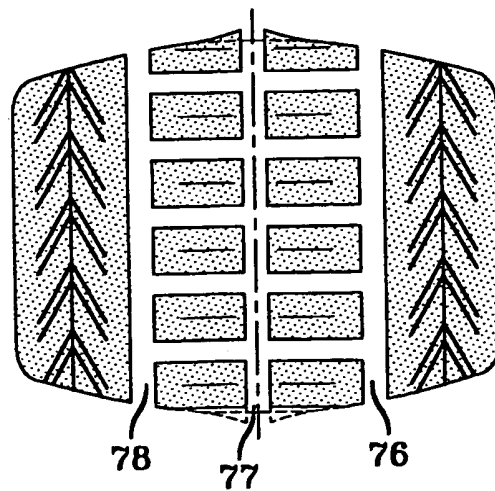


FIG-7

# INTERNATIONAL SEARCH REPORT

Inte: inal Application No

PCT/US 97/18031

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 B60C11/04 B60C11/13

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 475 (M-1186), 3 December 1991 & JP 03 204308 A (BRIDGESTONE CORP), 5 September 1991, see abstract	1,8
A	EP 0 305 617 A (SUMITOMO RUBBER IND) 8 March 1989 see claims; figures	1,8
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 177 (M-1582), 25 March 1994 & JP 05 338412 A (SUMITOMO RUBBER IND LTD), 21 December 1993, see abstract	1,8
-/-		

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

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- "&" document member of the same patent family

Date of the actual completion of the international search

4 June 1998

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/18031

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A	EP 0 600 177 A (GOODYEAR TIRE & RUBBER) 8 June 1994 see page 5, column 7, line 10 - line 19; claims 1,2,12; figures 2,6 see page 3, column 4, line 57 - page 4, column 5, line 11	1,8
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